Economics of Positive Train Control

No cogent public policy regarding Positive Train Control can be formulated until we know what the tradeoffs are. What benefits will PTC gain for us, and what will these benefits cost? The Implementation Task Force needed to review studies, such as the Corridor Risk Assessment Model, regarding where PTC may be needed. The Implementation Task Force has also heard competing theories regarding what business benefits may be derived from PTC. To resolve these issues, the Implementation Task Force assembled an Economics Team, and empowered them to study these issues and make consensus recommendations.

The Economics Team included members of management, labor, commuter railroads, and FRA. It was fortunate that one member of management, one representative of labor, and one representative of FRA on the Economics Team had been members of the Accident Review Team, which earlier had analyzed accident reports to determine which accidents were PTC-preventable.

PTC Benefits: Accidents Costs Avoided

The Team's first task was to assign costs to the accidents designated as PTC-preventable by the Accident Review Team. These costs were to be used as inputs for the Corridor Risk Assessment Model. The Corridor Risk Assessment Model measures the likelihood of certain occurrences, using a probabilistic model. It then assigns costs to these consequences in order to distinguish and prioritize among corridors. It may also be possible to estimate the expected consequences of these occurrences in a model using consequences as a dependent variable. In order to use either model we need to know the unit costs of various occurrences, such as fatalities, injuries, property damage and evacuations, the avoidance of which provides the direct **safety benefits** of PTC. It is desirable to estimate other costs, but the FRA accident report does not contain data on them. An example of such a cost is environmental clean-up. The Economics Team tried to limit the data on which its estimates relied to data on the Accident Reports, or otherwise in the CRAM database. The Economics Team was able to fashion several such estimates, and to provide some thought on others.

Fatalities

The first element on which the Economics Team reached consensus was on the willingness-to-pay to avoid a fatality, which the Team estimated at $2,700,000 per fatality. This number represents what society has been shown to be willing to pay for safety devices which will in the future avoid a fatality, and is a standard number used by all DOT agencies.

Injuries

The Economics Team also agreed to accept a value of $100,000 per employee injury avoided due to train accidents. The team considered the Accidental Injury Severity (AIS) scale, which DOT uses for comparisons of injury costs. This would imply an average injury on the low side of the interval between moderate and severe injuries, and uses a round number. There isn't much precision in this estimate.

Data from four commuter railroads indicates that their average payout per injury claim was about $35,000. This represents settlements and judgements. While the judgements probably reflect loss per claimant where the railroad was found liable for the injury to the claimant, there may have been injuries where the claimant was not successful. The settlements reflect the expected value of suits had they gone to trial, and reflect a reduction from the actual claim which is the risk that a claimant might lose were the case to go to judgement. From an economic standpoint who is liable for an injury is not relevant to the question of the societal loss caused by an injury. Further, the loss to society also includes the costs of administering and pursuing claims. Thus the fees paid to claimants attorneys, and the costs of defending and administering claims are also societal costs of an accident. If the average claimant received $35,000 it is not unreasonable to assume that the societal cost of an average passenger injury in real economic terms was roughly 50% greater, or about $55,000, a figure accepted as a consensus estimate by the Economics Team.

Equipment Damage

The Economics Team attempted to distinguish between the costs of equipment damage reported on the accident report and the actual loss to society of that damage. The Federal Railroad Safety Regulations require that the railroads report the depreciated book value of the equipment damaged if the equipment is destroyed. Otherwise, the railroads must report the estimated costs of repairs. The depreciated book value can be a poor estimate of the societal value of a car. A much better estimate is provided by concepts such as Economic Limit of Repair (ELOR).

Several major freight railroads utilize a concept and methodology called Economic Limit of Repair (ELOR) or Maximum Allowable Expenditure for Repair (MAER) to determine the value of existing equipment, particularly equipment being considered for repair or upgrade. Where estimated repair costs exceed the ELOR or MAER, the equipment is typically scrapped or placed in a heavy bad order status rather than repaired. The ELOR methodology typically considers contribution to revenue, replacement cost, salvage value, service life, repair life, and repair cost.

FRA incident reporting requirements dictate that equipment damage costs be the repair estimates for damaged cars to be repaired and depreciated book value for destroyed cars. However, the PTC Economic Team agrees that the ELOR or MAER values provide a more appropriate and accurate estimate of the pre-accident economic value of destroyed equipment than does the depreciated book value. Some railroads cooperated with the Economics Team to develop an analysis comparing the actual repair costs to the FRA reported values for repaired cars and MAER values to FRA reported values for destroyed cars. The study showed that the MAER values were very close, on the average, to the equipment damage numbers reported to FRA. There were some numbers much higher or lower, but the high and low values appear to offset each other, so the Team agreed to accept the value reported to FRA as the best estimate of actual damage.
The Economics Team also could not discern a difference between the reported costs of damage to passenger equipment and the societal cost of the damage. The Team agreed that the best estimator of passenger equipment damage is the reported damage. Passenger equipment is often insured for replacement value, so sometimes damaged equipment is overreported as the cost of replacement equipment. Other times the equipment is reported as the depreciated value of the equipment. There just doesn't seem to be a pattern which would enable us to use a scaling factor.

Track and Right-of Way Damage

It appears that actual damage reported for track and right-of-way damage is fairly accurate, and reflects societal costs. It may be underreported in some cases, but in other cases it may be overreported as older track and right-of-way may be repaired to better than pre-accident condition. This appears to the Economics Team to balance out over time, and not to be correlated with any reported characteristics. For purposes of this study the Economics Team agrees to use the reported damage to track and wayside.

Damage off the Right-of-Way

Some damage may occur to property not on the right-of-way, for example when an overspeed train derails, damaging a building owned by someone other than the railroad. The Economics Team estimated this damage at $2,000 per PTC-preventable accident[1]. Such damage is rare, and cannot easily be attributed to an accident based on any characteristics reported on the accident report form.

Hazardous Materials Cleanup

If an accident involves a release of hazardous materials, there may be a cost to clean up the hazardous material and remediate (restore) the environment. Based on data from actual settlements and judgements the Economics Team estimated the cost of cleanup and remediation at $250,000 per hazardous material car releasing. The Team considered using a single cost per incident in which hazardous material was released, but thought that it would be at least as good to base the estimated cost on cars releasing to provide some measure of the severity of the accident. This measure is still far from perfect, as some accidents involving single car releases may have resulted in far more costly clean-ups than some multi-car releases, yet it is the best measure the Team could agree upon.

Evacuations

Accidents may lead to evacuations, either because of real or perceived threats to safety from hazardous materials. The Team estimated the societal cost of an evacuation from data on 77 evacuations on which we had data on the duration of an evacuation. These accidents were not necessarily PTC preventable (most weren't) and occurred between 1993 and 1997. We estimated the value of time at $11.70 per hour, plus 30%, or $15.21 per hour. We added 30% to reflect the involuntary nature of the costs imposed. Unfortunately, one accident, at Weyauwega, Wisconsin, on March 4, 1996, dominated the costs. The Weyauwega evacuation lasted 426 hours, while the next longest lasted 43 hours. The average cost per evacuation was $986 with the Weyauwega evacuation, and $267 without. The Weyauwega evacuation was clearly an outlier, but nevertheless relevant, so the Economics Team compromised on an estimate of $500 per evacuation.

Loss of Lading

If there is an accident involving a loaded freight car, there may be a loss to society as a result of loss or damage to lading. In this case railroad payments to shippers are probably very close to the societal cost of lading loss and damage, which based on AAR data is roughly $6,500 per loaded freight car derailed, a figure the Team agreed upon.

Wreck Clearing

If locomotives or cars are derailed or destroyed, the railroad would need to remove them from the right of way. This cost includes the cost of mobilizing a crane or rerailing equipment to the accident site and the cost of employing that equipment. The Team estimated that the cost of mobilizing equipment to an accident site is $2,500 per incident where cars or locomotives are derailed. Once the equipment is there the Team estimated that it would cost $750 to rerail, wreck or transport a freight locomotive which had derailed, and $300 to rerail, wreck or transport a derailed freight car.

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Rerailing passenger equipment can be far more costly. The equipment is more expensive, and may be less robust than freight equipment. It needs to be handled with more care. The sites of passenger accidents are more likely to be in urban areas where the right of way is constrained, as in tunnels and sunken routes under streets. Further, the NTSB is far more likely to investigate a passenger train accident, so there may be significant costs while the rerailing/wrecking equipment sits near the accident site, awaiting NTSB's permission to clear the accident. Four commuter railroads' data suggests that the cost per incident of clearing equipment is roughly $75,000 per accident in which passenger cars or locomotives are derailed. The Team agrees with this estimate.

Delays

If a train is derailed it will block the track it is on, and may block adjacent tracks. The Team estimated that the average blockage would last two hours, so if the average affected freight train arrived randomly, the average train delay would be one hour, for freight trains, and fifteen minutes for passenger trains, which are likely to be switched around a delay, and would affect the trains that would pass over an average segment of rail in two hours. The Team estimated the average cost per hour of freight train delay at $250 per hour. Thus the estimated cost of a delay would be freight trains per day divided by twelve (the expected number of trains in two hours), times one (the average expected delay) times the cost per hour of a delay ($250).

The Team estimated the cost of passenger train delays, based on 285 passengers per train (a national average), an average duration of blockage of 2 hours (which implies passenger trains per day/12 are affected), an average per train delay of 15 minutes, and an average value of passenger time of $25 per hour. This relatively high per hour value of time is related to the income of train passengers. Many commuter lines have average passenger household incomes in excess of $75,000 per year. This works out to $148.44 times passenger trains per day.

System Unit Costs

The Economics team attempted to develop system unit *costs* for any elements of PTC systems likely to be found in multiple architectures, for instance, costs of on-board processors, DGPS receivers, wayside interface units, other wayside costs, additional sensors, transponders, track circuits, and communication systems, and data radio systems, as well as software development costs.

The biggest problem the Economics Team faced in this task was that different architectures would yield dramatically different unit costs for components, although if a system is under legitimate consideration it is unlikely that its total cost would be radically different from the total costs of other systems providing similar levels of function. One system might rely more heavily on central control, another more heavily on distributed intelligence. A key factor is the existing infrastructure and relative concentrat ion of various assets. A railroad which owns a significant communications infrastructure which could be used for PTC might face lower costs for a PTC system which is communications intensive. A railroad which has long expanses of track and relatively few trains would be more sensitive to wayside costs, where a railroad operating many trains in a dense corridor might be more sensitive to locomotive installation costs.

The Economics Team settled on costing a system with a significant central component for levels 2, and 4, a wayside centric system for level 3, and a train centric system for level 1[2]. The Team realizes that other concepts exist, and may be equally viable, but we needed to look at a single concept in order to generate a meaningful cost analysis.

Another issue is effectiveness. The Economics Team effort was designed to go hand-in-hand with the efforts of the Accident Review Team and the CRAM study. The CRAM will look at accidents which the Accident Review Team said were PTC-preventable and use a Poisson regression to correlate the accidents with other variables. In such a model an accident is either preventable or not (excluding accidents which the Accident Review Team designated as “maybe” preventable). Implicitly the CRAM assumes 100% effectiveness. It wouldn’t be helpful to use the CRAM to analyze PTC systems with very different effectiveness. For example, one level 2 system might always apply the brakes in a certain conditions, while another might just require the train crew to acknowledge the potential conflict. The system which allows the train crew override might not be as effective, although it might be considerably less expensive, and might be a valid approach to improving safety. Nevertheless, it wouldn’t make sense to use the CRAM to compare those two systems. Systems at all levels need to be nearly 100% effective in order for the CRAM results to make sense, thus the Team added costs to some proposed systems which only address Level 1 in order to make them comparable with higher level systems. This does not imply any acceptance or rejection of other concepts by the Team. It reflects the need to make simplifying assumptions to make study of the problem manageable.

There are three main types of costs. There are costs per locomotive or power unit, to cover the installed on-board equipment. There are cost per mile which reflect the costs of installing equipment along the right-of-way. These cost can either be per track-mile, for items which go into the track, such as switch position indicators, or per route-mile, for items like communications. The last category are single unit costs. These can cover hardware for a central office or intellectual property like software/

hardware development. Each of these types of costs involves an initial expenditure, and maintenance. The Team estimates that maintenance will cost 10% of the initial cost per year in service.

The Team agreed that costs per locomotive/power unit varied, depending on the level. For level one systems, which could involve only communications to prevent train-to-train collisions, and which might not prevent a train from running through a switch, there would be much less need for communications with the right-of-way, and a much simpler database could be used. The on-board costs, as agreed by the Team, would be about $40,000 per unit. Systems which could perform at levels 2, and 4 would need to get data from the right-of-way and respond to it. Systems at level 3 could use an ITCS-like architecture, and keep more of their computer intelligence on the wayside, reducing the burden on the on-board computer system. That would reduce the per unit on-board cost to about $50,000, compared to about $75,000 for levels 2 and 4. The differences between systems for level 2 and 4 would be in the number of devices communicating with the train, not in the train's response to a communication, therefore the Team estimated that regardless of whether a system was to perform at level 2, or 4, the cost per unit would be the same, $75,000 per locomotive/ power unit.

Costs per mile depend on the level of PTC adopted and the existing infrastructure. Most systems used some similar components, so the Team estimated unit costs as follows:

PTC System Component Costs

WIU	$40,000
Track Circuits/mile (with WIU)	$15,000
Switch Monitor	$10,000
Bridge Monitors	$40,000
Wind Monitors	$15,000
Defect Detector Monitor	$10,000
Base radios	$45,000
Yard radios	$10,000
DGPS	$20,000
Wayside servers	$65,000

PTC System Wayside Costs

Costs per Route Mile

Level	CTC	ABS	Dark
1	$0	$0	$0
2	$2,890	$4,890	$4,890
3	$10,890	$12,890	$12,890
4	$43,070	$45,070	$45,070

Costs per Track Mile

Level	CTC	ABS	Dark
1	0	0	0
2	0	0	0
3	$23,125	$23,125	$23,125
4	$20,000	$65,000	$65,000

Route Mile Costs

	Miles Spacing	Unit Costs	Per Route Mile Costs
Base station radios	20	$45,000	$2,250
Yard Radios	250	$10,000	$40
DGPS (in addition to Federal DGPS)	200	$20,000	$100
			=========
			$2,390
Bridge Monitors	2	$80,000	$40,000
Wind Monitors	250	$45,000	$180
Defect Detectors in Dark and ABS	20	$50,000	$2,500
Defect Detectors in CTC	20	$10,000	$500

Track Mile Costs

CTC $50,000 Switch monitor +WIU
2 Switches
5 Miles between un-monitored switches

$20,000 per track mile for Switch monitors

ABS/Dark $50,000 Switch monitor
1 Switches
1 Miles between un-monitored switches

$50,000 per track mile for Switch monitors

Level 3
$23,125 Wayside server + 3 WIU per eight miles

PTC System Locomotive Costs	Unit Cost	Offset by Planner[3]	Adjusted Cost
Level 1	$40,000	$27,000	$13,000
Level 2	$75,000	$27,000	$48,000
Level 3	$50,000	$27,000	$23,000
Level 4	$75,000	$27,000	$48,000

PTC System Development Costs		Offset by Planner	Adjusted Cost
Level1	$20,000,000	$3,000,000	$17,000,000
Level 2	$30,000,000	$3,000,000	$27,000,000
Level 3	$40,000,000	$3,000,000	$37,000,000
Level 4	$50,000,000	$3,000,000	$47,000,000

Costs per route-mile of communications were estimated at $2,390 per route-mile. This was based on estimates for a Western railroad, using existing infrastructure where possible. A railroad with less infrastructure would face higher costs, while one with more infrastructure would face lower costs. Level 3 systems, which under this analysis would rely on wayside computer intelligence, would have additional costs of $23,125 per route mile, which would include costs for WIU's every two miles, with every fourth WIU including a server. For level 4 systems, which would need to include bridge motion detectors, there would be an additional cost of $21,000 per route-mile. This cost would be lower if fewer bridges were monitored. This might be feasible if the definition of bridge were changed to only include bridges longer than 20-40 feet, rather than the current definition of longer than 10 feet (the Economics Team is not making any recommendations with respect to the definition of a bridge). At the same time, reducing the number of bridges monitored by PTC would reduce the benefit.

Costs per route mile include the cost of installing wayside interface units (WIU's). It appears that WIU's will cost about $40,000 each, on average (the actual cost of WIU's is expected to range widely, depending on existing infrastructure and type of WIU), and will cost about $2,875 per route mile for levels 2, 3 and 4. This would be sufficient to achieve Level 2 in Dark, ABS or CTC territory. The WIU cost is different for various types of WIU, but this seems to be a representative figure.

To get higher levels of function, we would have to add more detectors. To achieve Level 4 would cost $39,000 per track-mile in dark territory, $30,000 per track-mile in ABS territory, and $6,000 per track-mile in CTC territory.

Single item costs include software development and, if needed, central office costs.

Alternatives to PTC

No economic analysis would be complete without a discussion of alternatives. The accidents which PTC might prevent may also be avoided through other means. While these means may not be as effective in preventing the same pool of accidents, they may be able to address some of the same accidents, and others outside the PTC-preventable pool. Three major areas of potential improvement include addressing human factors in accidents, signalizing dark territory, and enhancing existing signal systems. In addition, advocates of PTC have suggested that PTC may bring various business benefits. There may be other ways of generating similar business benefits.

The FRA is addressing Human Factor issues in several other initiatives:

Fatigue: FRA's goal is to continue to expand Fatigue Countermeasure Programs by: (1) providing leadership to the rail industry in researching and developing fatigue countermeasures through FRA's North American Rail Alertness Partnership; and (2) include language in the 1999 Safety Reauthorization Legislation for the Hours of Service Law.

Cab Working Conditions: FRA's goal is to improve the safety and health of cab occupants. Early in the year, we will endeavor to complete RSAC's consideration of a proposed sanitation standard. During the same period it will be necessary to determine if a current impasse on high-end temperature issues can be resolved so that rulemaking (either under an RSAC consensus or otherwise) can proceed. Later in the year, detailed issues related to cab noise should be resolved, permitting institution of rulemaking on that subject.

Although FRA has established these goals, railroad management and labor organizations have not yet adopted them, and reserve their rights to disagree with FRA.

Conventional Signal Systems

Signal systems which don't qualify as PTC still hold considerable promise in reducing accidents. In dark territory signal systems could make existing operations safer, helping train crews avoid many PTC preventable accidents. Some of these accidents might still occur, but signalization is still a valid safety-improvement strategy. In areas where signal systems are in place improving the signals could help avoid PTC preventable accidents. This study does not purport to analyze the benefits or costs of these competing safety improvement strategies, but identifies them for others who may wish to analyze them.

Railroad signal systems are valuable assets to transportation safety. They comprise a critical element of the safe and efficient operation of a railroad. The utilization of signal systems provide for the safety of local residents, railroad employees, equipment and commodities. There are many well-established safety benefits afforded to signal systems. Signal systems presently utilize a fail-safe design and are designed to protect the safety and integrity of railroad operations by providing broken rail and track defect protection, switch and derail alignment protection and route integrity protection, not to mention protection against different types of train and on-track equipment collisions. Furthermore, signal systems are designed to mitigate the dangers caused by human error or acts of vandalism. They also provide additional protection to the sometimes-fragile environments which many segments of track traverse. By providing track integrity protection, additional signal systems could ensure a safer passage for the multitude of hazardous materials that are transported by train throughout the nation. Signal systems also provide an added level of protection for inland waterways, bridges, trusses and culverts that are spread throughout each individual railroad. Enhancing the existing train control system on a specific route might provide some of the same safety benefits as those associated with PTC systems. An analysis has not been done that describes the relative cost/benefit improvements available to such systems.

Locomotive Crashworthiness:

Although we would rather prevent accidents than mitigate them, our goal is to enhance the protection of locomotive crew members in serious train accidents. As 1998 ended, tentative agreement had been reached on the basic elements of crashworthiness for freight road locomotives, and work was proceeding on passenger locomotives. During 1999, an NPRM will be completed and comments will be received.

Passenger Equipment Safety Standards

Concurrent with this review of positive train control implementation, which will enhance the crash avoidance capabilities of the national rail system, FRA and the passenger rail industry are also considering ways to strengthen locomotives and passenger cars. The RSAC Locomotive Crashworthiness Working Group, the FRA's Rail Passenger Equipment Rule and the American Public Transit Association's Passenger Rail Equipment Safety Standards effort are all defining standards that will make rail vehicles more crash resistant. Enhancing both crash resistance capabilities with sturdier rail vehicles and crash avoidance capabilities with positive train control are efforts that have significant financial implications for the passenger railroads and the potential to reduce the same group of fatalities and injuries. Because of the overlapping nature of these efforts, FRA needs to ensure that the cost benefits analysis of crashworthiness and crash avoidance are linked and do not double count potential benefits.

Other Than Safety Benefits

Because PTC systems have been expensive, there has been thought that consideration should be given to incremental economic benefits which could be achieved through improved railroad operating performance (i.e. not just safety), to help justify the cost. This assumes that there is a synergistic, but dependent relationship between the basic safety system and the operating algorithms needed to improve daily performance. This assumption is true of one particular design philosophy, i.e where safety hardware and software form the foundation of all other systems. However, suppliers in the industry are marketing technologies which they believe would improve operating efficiencies independent of PTC safety systems and at considerably less cost.

At the same time, however, some train control systems designed for safety purposes appear to share many characteristics with systems designed to increase productivity. Both types of system need to know the location of the trains, and may need to inform the train of the actions the system needs the train to take. On-board the locomotive either system needs to have location equipment and may need equipment which takes commands from the system. Each system needs to communicate. Each system must be developed to process logical information regarding the trains' current and future positions.

An important consideration on how much overlap there might be between the technology a railroad might adopt for PTC and the technology a railroad might adopt for planning is the current state of the railroad's infrastructure. Railroads vary widely in their existing infrastructure. Some have more extensive existing communications networks while other railroads have very limited communications networks, leasing the communications capability for business systems. Infrastructure can also vary in terms of miles of multi-track line and traffic density. All of these may affect whether part of the PTC investment might be used for business planning systems.

Dependent Systems

As stated earlier, one PTC design philosophy assumes that safety hardware and software form the foundation of the system. The primary benefit is safety, i.e., prevention of train collisions and over speed operations, as well as protection for roadway equipment. Safety is absolutely dependent on the function of this technology. Thus, these systems require varying degrees of vitality, depending on their individual design, which necessitates high reliability in hardware and software. They also require a communications infrastructure (not currently in place) which is capable of handling high data throughput. The communications infrastructure alone can cost as much as $200M per railroad. Together, these attributes require the greatest amount of capital and make the system cost quite high.

Within this philosophy, additional economic benefits can be achieved with incremental capital investment since much of the hardware and software is already in place. The largest benefits include the potential for reduced manpower requirements, elimination of existing wayside signals, increased infrastructure throughput (capacity), equipment utilization, and fuel savings. Of these benefits, only the elimination of wayside signals and the potential for reduced manpower (which is outside of the scope of this report) are truly dependent on the vitality required for the PTC safety systems. (In fact, additional vitality may be required for these concepts.) The remainder can be achieved independent of the PTC safety systems.

Independent Systems

Suppliers are offering systems which may offer much of the benefit previously thought to be dependent on the advent of Positive Train Control, independent of the PTC systems, and at considerably less cost. Most of the benefit comes from improvements in infrastructure throughput, equipment utilization, and fuel savings. Each of these is dependent on the presence of a network system planner, a location determination system placed on board most locomotives, and sufficient communications infrastructure to communicate position and pacing information.

Infrastructure Throughput

A railroad computer based network planner can prioritize the movement of trains such that it may improve overall throughput. The use of a network planner seems to be a prudent business practice, independent of the advent of PTC. Planning is accomplished by organizing the travel sequence for all trains in an entire marketing corridor or network. The plan is based on required schedule, the consist size, yard holding capacity and commodity. Some planners are capable of addressing anomalies in the plan such as locomotive failure, slow order or derailment. They make repairs to the plan for all trains affected by the event. The overall result of these capabilities is improved equipment velocity and throughput. In a March 1991 technical evaluation, Stanford Research International reported that 70 percent of the total benefits of the ARES (PTC) functions could be achieved through the planning system - the "largest contributor to the net present value...".

The success of this theory is dependent on two factors: that the new planner is better than that which is used currently and that there is sufficient business to warrant or enable an improvement. Independent studies by individual railroads have shown the relationship between business level and planner benefit. The relationship is marketing corridor dependent. Without sufficient business or congestion, there is little need for these systems.

Benefits may also be achieved when the need for additional track is delayed or eliminated because the planner has made the existing infrastructure more productive. In either case, there is a financial offset to the investment required.

Equipment Utilization

With improved planning and increased velocity, the number of units of equipment needed to service the current traffic can decrease. Improved planning has the potential to reduce the overall locomotive fleet size required to serve the network. Improved car velocity can increase the number or turns of cars achieved annually. While this is somewhat dependent on the release of the equipment by customers following delivery, the potential for savings is certainly present. The improvement is business level dependent, i.e. higher levels of business are required for justification.

Fuel Savings

Because of the potential for pacing of trains in the planning scenario, locomotive fuel consumption should improve. The potential savings amounts to a few percent of the railroads fuel bill in the marketing corridor. Again, there must be sufficient business level in the corridor to realize the improvement.

Balancing Cost and Benefit

Railroads the size of the four major systems in the United States could spend on the order of $500M to $600M each on full PTC systems that provide both safety and productivity improvements on core routes. The investment required for productivity improvements alone is roughly 20 to 25 percent of the capital required for full PTC , while 70 percent or more of the benefit can be achieved. In either case, the return on the investment will be dependent on the business level in the marketing corridor.

Through the Volpe National Transportation Systems Center, FRA had commissioned a study of other-than-safety benefits of business systems associated with PTC. The study analyzed the benefits of business systems associated with PTC and concluded that these benefits fell into five categories:

reduced yard and transit time from improved work order reporting;
reduced maintenance hours and en-route failures from locomotive diagnostics;
fuel savings;
reduced costs from improved equipment utilization and
higher revenue from improved customer service.

FRA further believes that systems associated with PTC can contribute additional benefits by providing current information which can help with crew scheduling and profit maximization. The systems may also help identify less efficient operations within a railroad, enabling the railroad to improve the effectiveness of its middle management, and may help the railroad better target other infrastructure improvements.

A railroad might achieve these benefits by adopting a network system planner, a location determination system and sufficient communications infrastructure to communicate position and pacing information. These can be purchased independent of a PTC system, but once you have decided to pay for these, it may be less expensive to add a PTC system because it relies on the same information. A PTC system would need location determining equipment, and equipment to communicate position and might need equipment to receive pacing information. A PTC system also needs some processing capacity to ensure train separation. This processing capacity is similar to the capabilities needed to support a traffic planner.

The Economics Team estimates that the cost of a PTC system may be offset by about $27,000 per locomotive/power unit, and about $3,000,000 for development. Onboard equipment cost is partially offset because the PTC system would have to include positioning equipment and a data screen sufficient to execute the requirements of a planning system, and the communication system required for PTC would obviate the need to purchase commercial communication for the planner. In addition, the software team developing the planner or PTC would benefit from their knowledge of the railroad's operation were they to develop a PTC system or planner subsequently, would be able to reuse code dealing with processing positioning messages, and would be able to make dual use of the track database.

The Economics Team noted that if there were great benefits to be gained be adopting a planner, then a planner would likely be implemented without regard to PTC implementation. Thus the absolute magnitude of benefits from the planner is not relevant, as long as the benefits of a planner far exceed its costs. What is relevant is the synergistic relationship between the planner's development and development of a PTC system.

Integrating the Benefit Analysis with the Cost Analysis

The benefits of a PTC system on a Corridor can now be estimated using the Corridor Risk Assessment Model. Once that is done, the costs of installing PTC on those corridors can be estimated using the unit costs developed here. These unit costs cannot be applied until we estimate the number of locomotives which must be equipped in a corridor.

[1] Yard and highway-rail grade crossing accidents are excluded from any definition of PTC preventable accident considered here.

[2] In a wayside centric system much of the computer processing is done at wayside units, while in a train centric system much of the computer processing is done on-board the locomotive.

[3] See the discussion of other than safety benefits below. The Economics Team agreed that the best way to account for business benefits was to accept the common costs shared by PTC systems and planning systems as a reduction in the cost of PTC items, rather than accepting business benefits as an addition to PTC benefits. A planning system is a computer driven system which manages the trains operating over a railroad in order to optimize throughput or profit.